Seasonal sea surface temperature anomaly prediction for coastal ecosystems

Seasonal/Decadal Predictions for marine resource management
June 3, 2015, Princeton NJ

Charles Stock (GFDL), Kathy Pegion (GMU), Gabe Vecchi (GFDL), Mike Alexander (ESRL), Desiree Tommasi (GFDL), Nick Bond (PMEL/JISAO), Paula Fratantoni (NEFSC), Rich Gudgel (GFDL), Trond Kristiansen (IMR), Todd O'Brien (NMFS S&T), Yan Xue (NCEP/CPC), Xiasong Yang (GFDL)

Progress in Oceanography, accepted pending minor revision

Predictability of SST anomalies in shelf ecosystems

- SST anomalies are both leading indicators and important drivers of ecosystem fluctuations
- Assessment of SST predictions has been strongly skewed toward basin-scale variations (e.g., ENSO) and SSTs often viewed as precursors to predicting regional air temp/precip anomalies
- For marine resources, SST anomalies are of direct interest, and predictions along continental margins are essential

Challenges

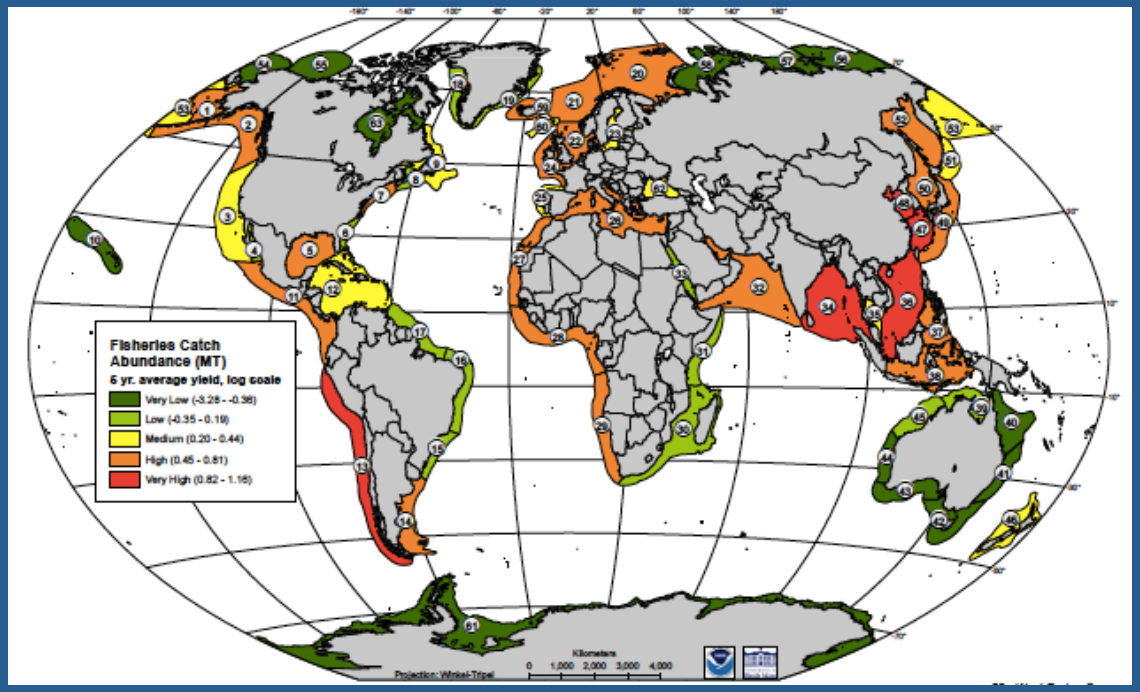
- Global SST reanalyses used as “observations” in evaluating predictions can be challenged in coastal systems
- Coarse resolution of global forecast systems may degrade coastal forecast skill
- Prominent sources of unpredictable local variation may “swamp” signals from more predictable large-scale patterns

Questions

- Can present global climate prediction systems provide skillful SST anomaly predictions at coastal scales?

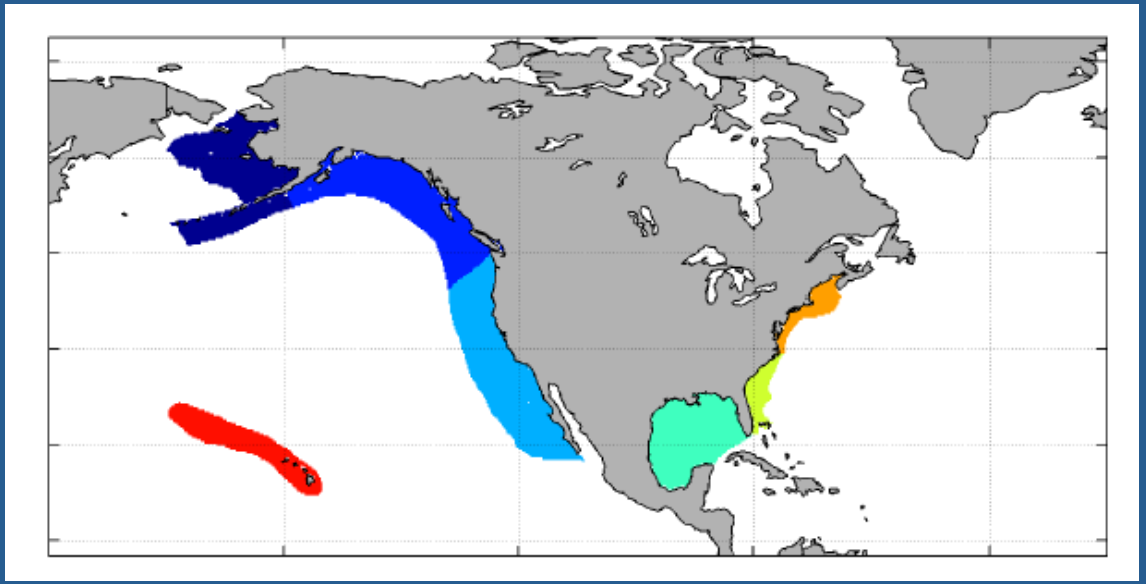
- If so, what mechanisms are responsible for this skill?

Synthesize predictability across Large Marine Ecosystems (LMEs)



Large Marine Ecosystems: Ocean areas, generally along continental margins whose ecological systems are characterized by similarities in bathymetry, hydrography and biological productivity, and whose plant an animal populations are inextricably linked to one and other in the food chain (Sherman and Alexander, 1986)

Synthesize predictability across Large Marine Ecosystems (LMEs)



- 7 LMEs for detailed analysis of past anomalies, predictability, and mechanisms underlying skillful predictions
- Exploratory look at global LMEs informed by mechanisms elucidated by detailed analysis of 7 systems.

Reynolds-OISST.v2 consistent with "raw" WOD13 data in 6 of 7 coastal LMEs

LME	Reynolds–WOD13 Correlation	Reynolds-WOD13 Amplitude ratio
East Bering Sea	0.76	0.88
Gulf of Alaska	0.85	1.03
California Current	0.84	0.90
Gulf of Mexico	0.82	0.90
Southeast U.S.	0.45	0.68
Northeast U.S.	0.87	0.89

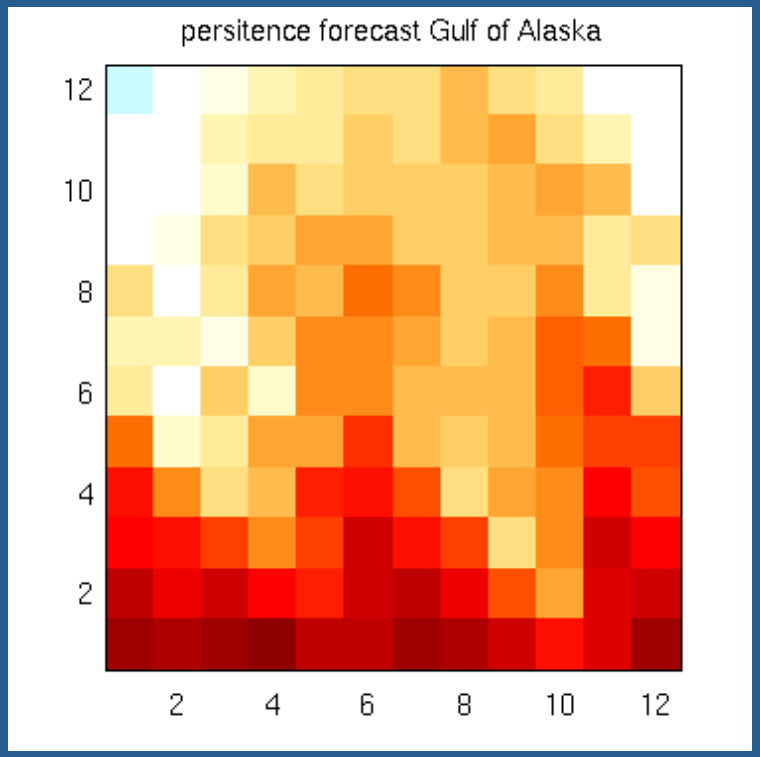
Focus on two forecast systems:

Component	GFDL-FLOR	NCEP CFSv2
Reference	Vecchi et al. (2014)	Saha et al., (2014)
Atmospheric/Land Resolution	50 km x 50 km	100 km x 100 km
Ocean/Sea Ice	GFDL-MOM4p1 ~100 km x 100 km	GFDL-MOM4p0 50 km x 50 km
Forecast Initialization	ECDA (Zhang et al., 2007)	CFSR (Saha et al., 2010)
Forecast Ensemble (1982-2010)	12, 12 month forecasts started on 1st of each month	4, 9 month forecasts started every 5th day

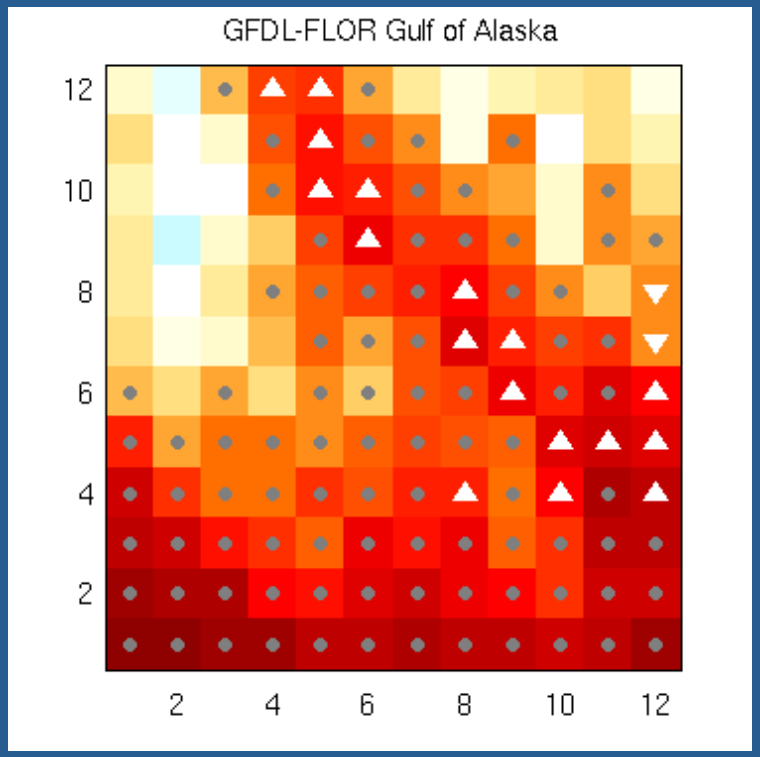
Can obtain from NMME: http://www.cpc.ncep.noaa.gov/products/NMME/

Gulf of Alaska SST anomaly predictions

Persistence ACC



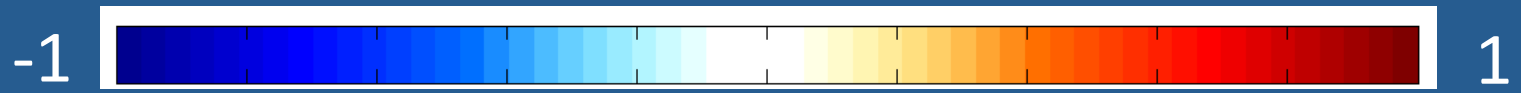
GFDL-FLOR ACC



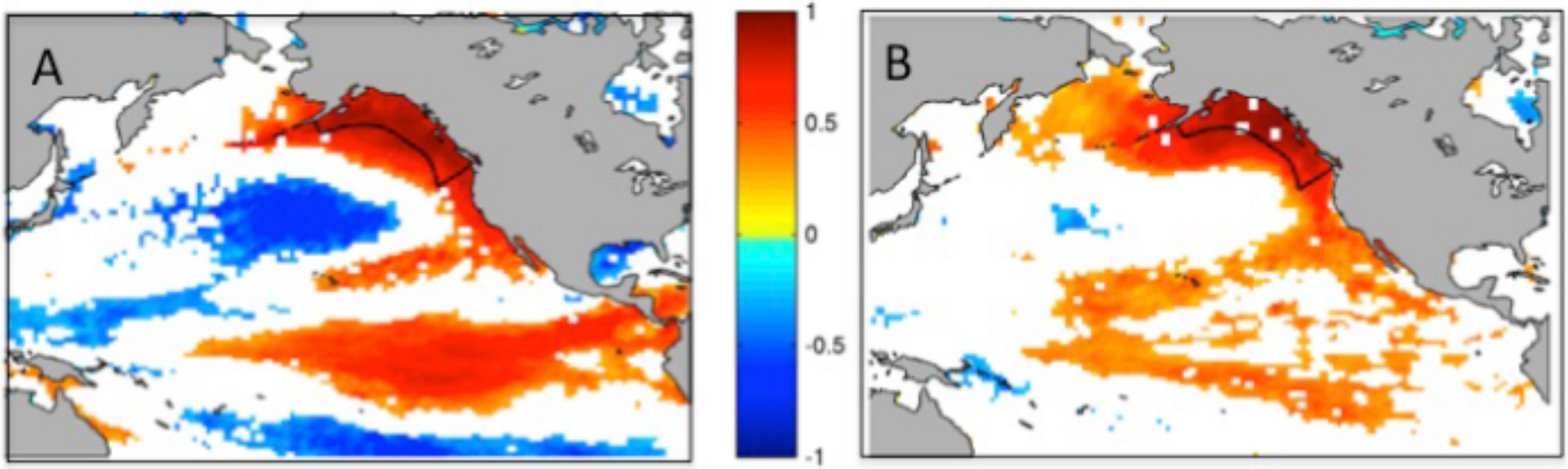
Forecast lead (months)

Forecast initialization month

Forecast initialization month



Forecast captures seasonal transition between less predictable localized SST anomaly and more predictable basin-scale patterns

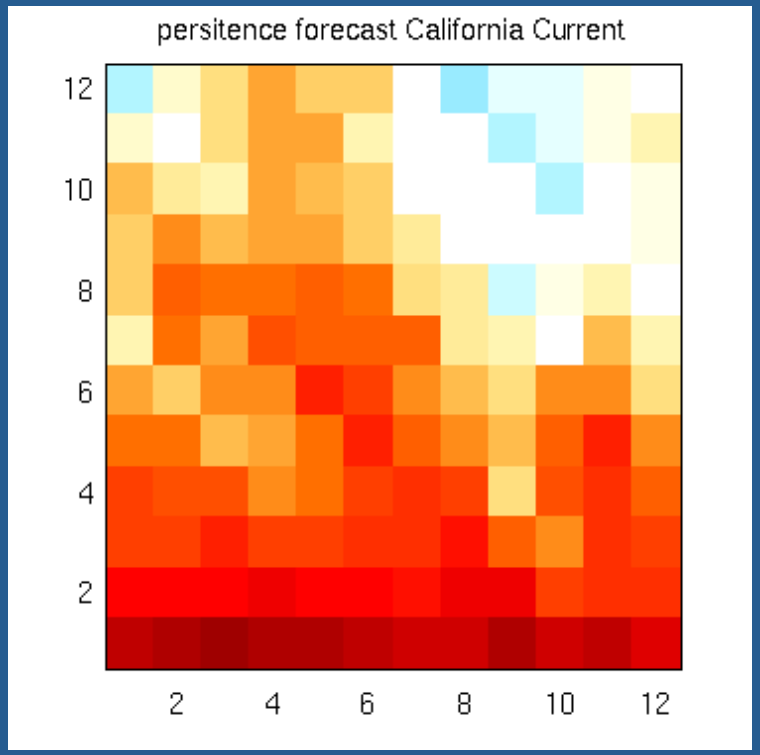


Correlation between March GoA SST anomaly and SST anomalies over the North Pacific Basin

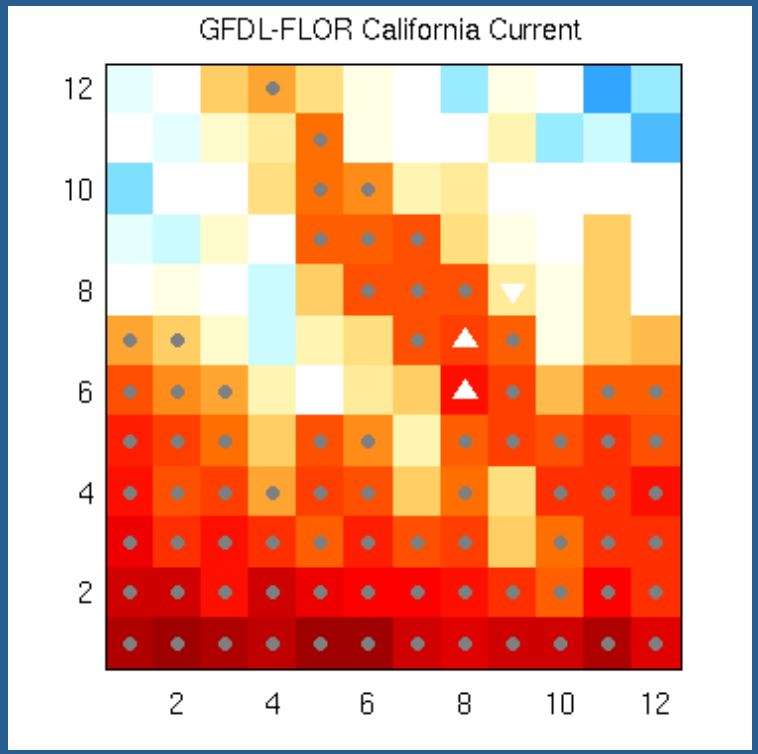
Correlation between August GoA SST anomaly and SST anomalies over the North Pacific Basin

California Current patterns similar to GoA but as separable from persistence

Persistence ACC



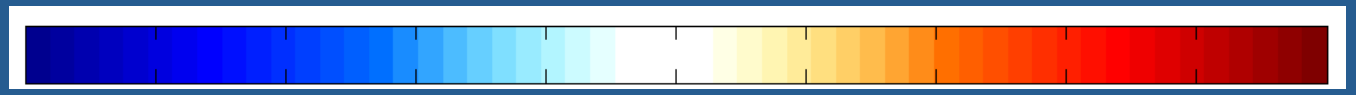
GFDL-FLOR ACC



Forecast lead (months)

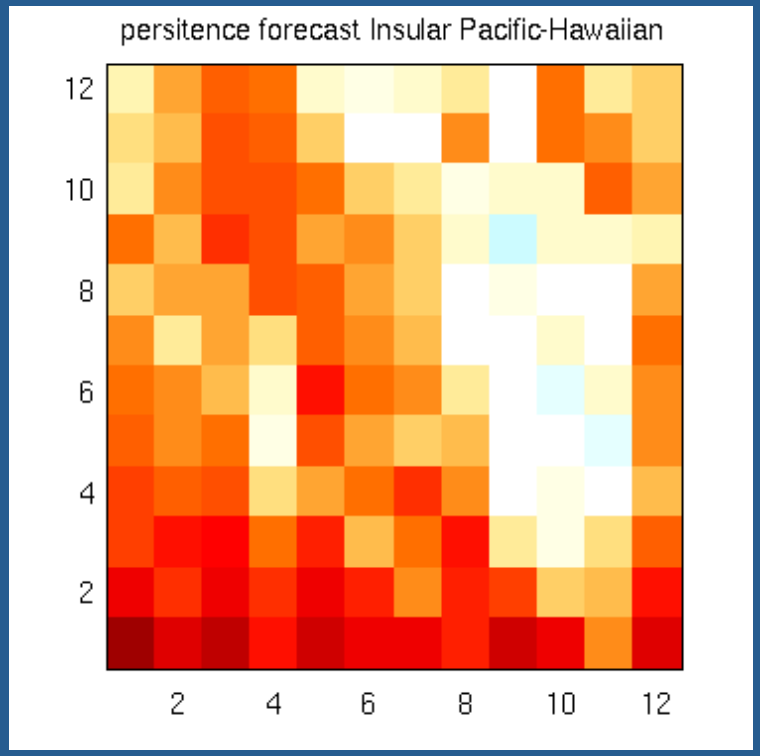
Forecast initialization month

Forecast initialization month

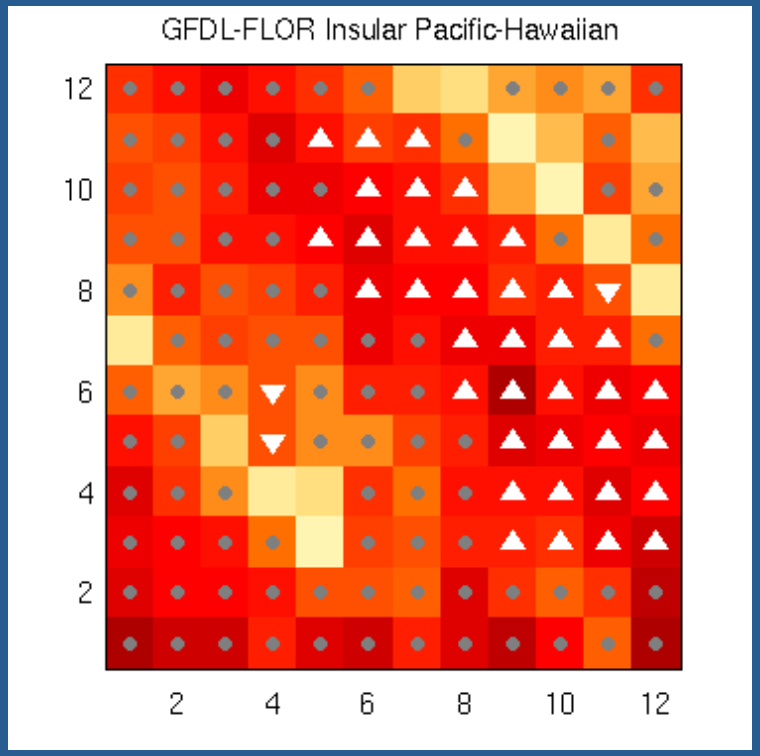


Insular Pacific/Hawaiian (IP/H) SST anomaly predictions

Persistence ACC



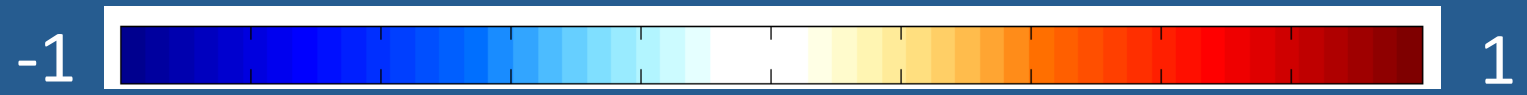
GFDL-FLOR ACC



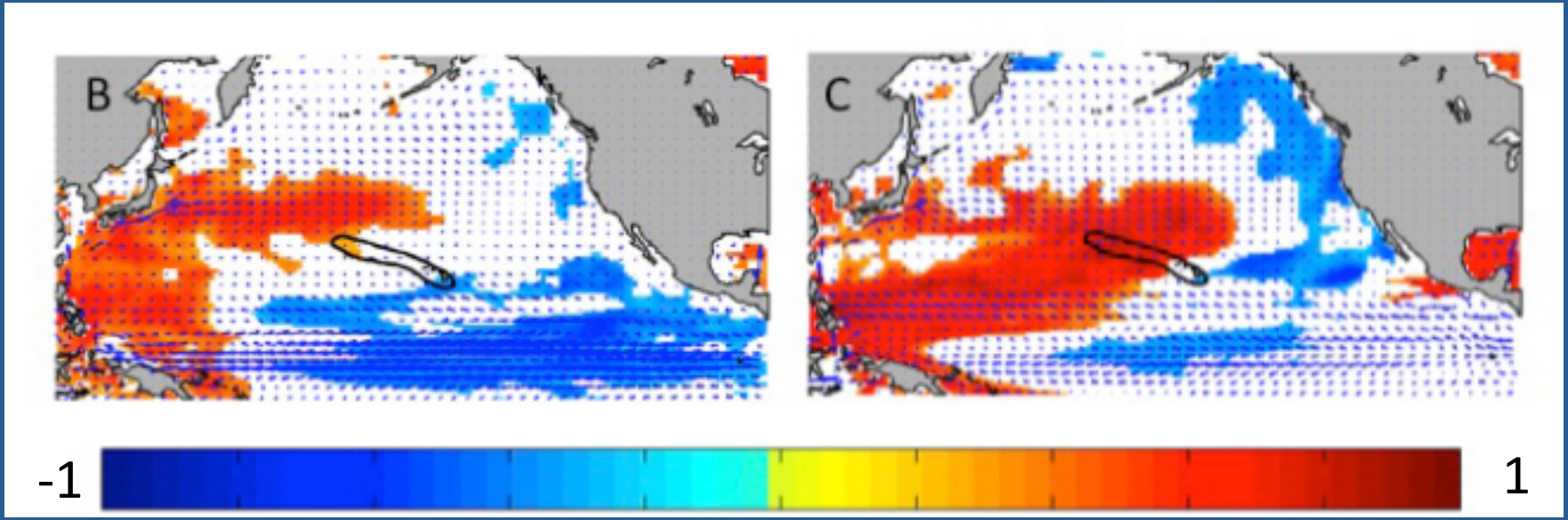
Forecast lead (months)

Forecast initialization month

Forecast initialization month



Forecast captures seasonal transition between different basin-scale influences

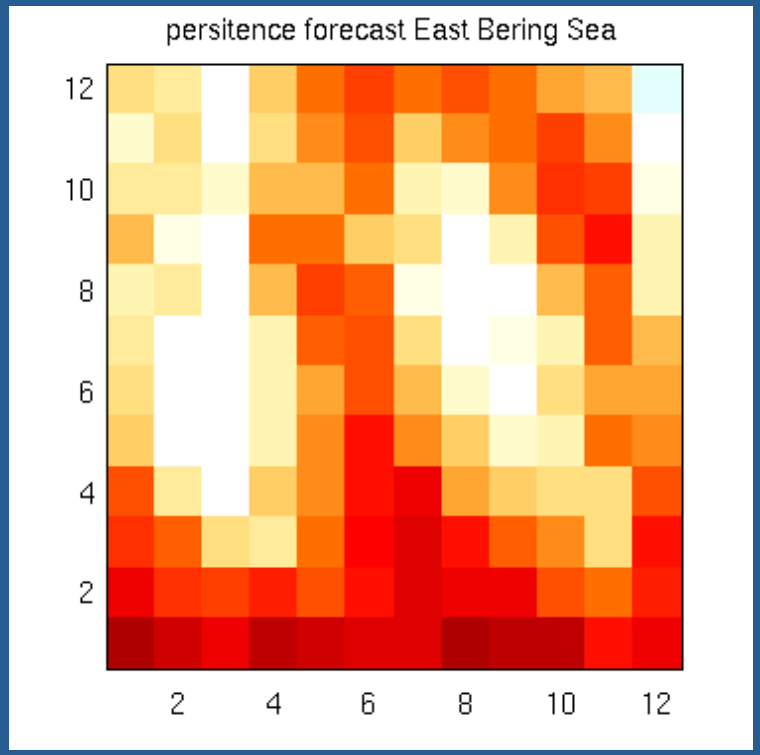


Correlation between Sep initialized SST anomaly and predicted Jan-Mar SST anomalies in the IP/H

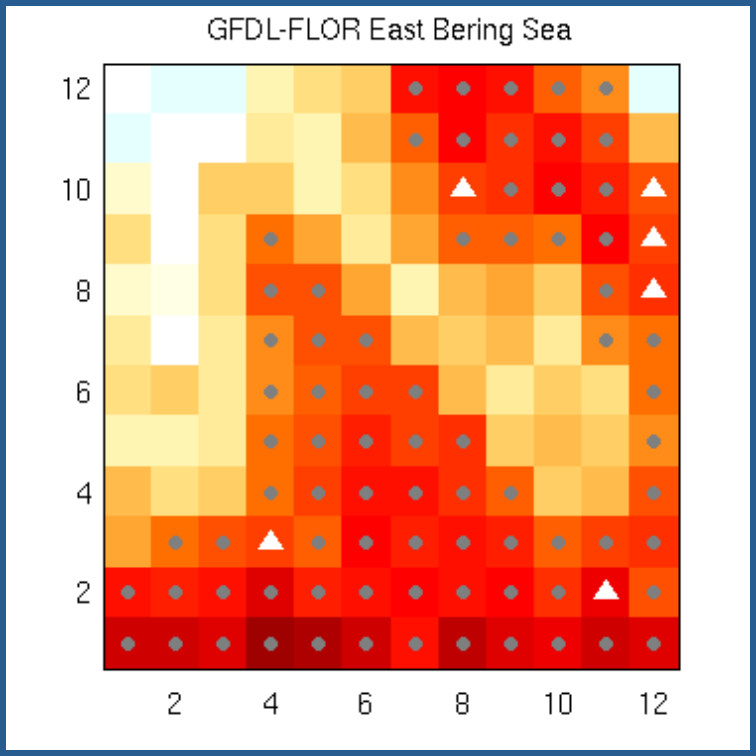
Correlation between Feb forecast from Sep initialization and Jan-Mar IP/H anomalies

Bering Sea SST anomaly predictions

Persistence ACC



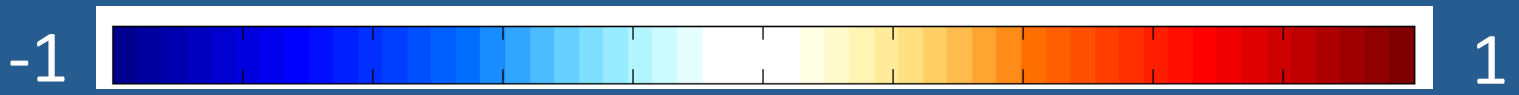
GFDL-FLOR ACC



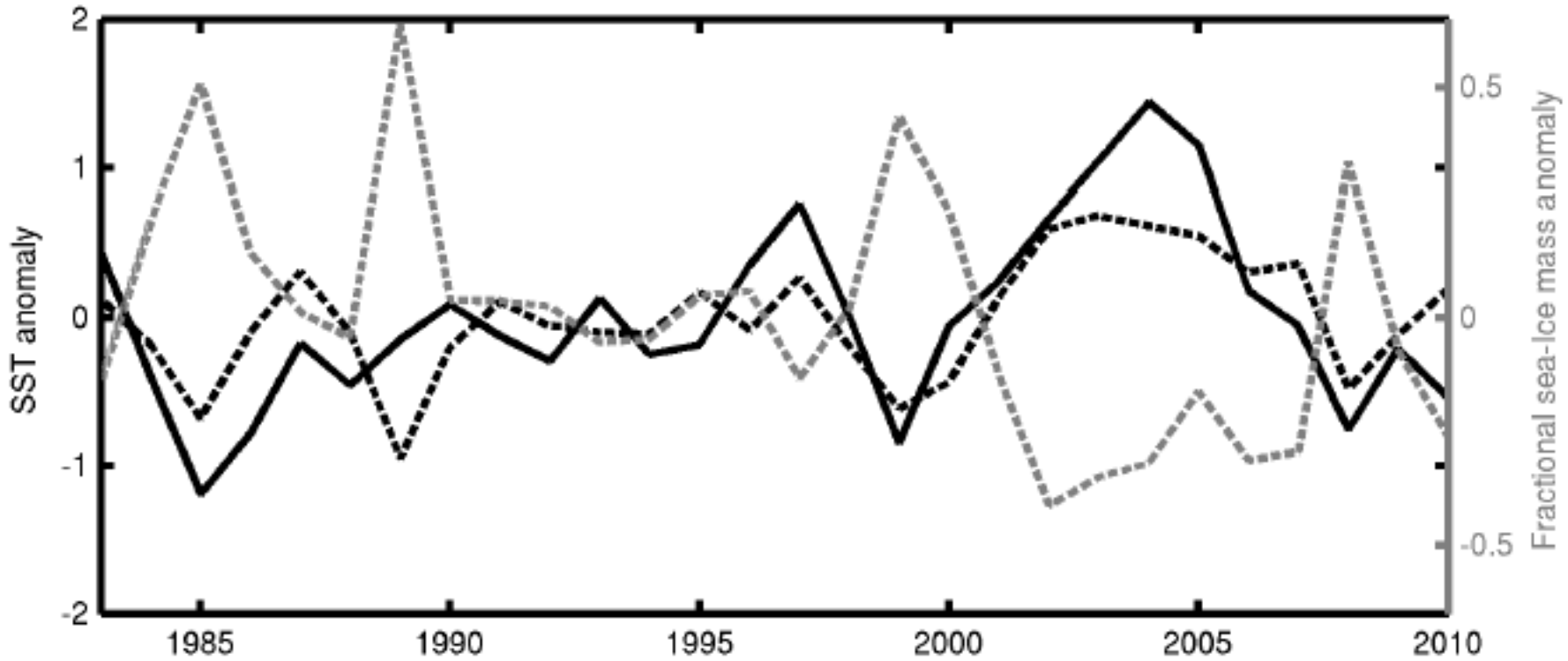
Forecast lead (months)

Forecast initialization month

Forecast initialization month

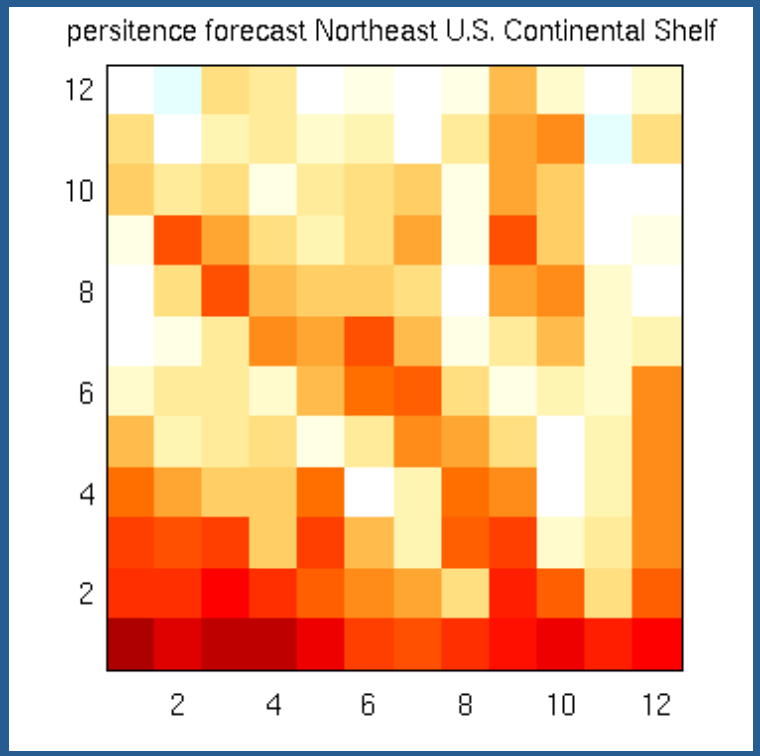


Sea-ice serves as a reservoir for propagating SST anomalies across the winter



Smaller scale is challenges forecast systems in the Northeast U.S

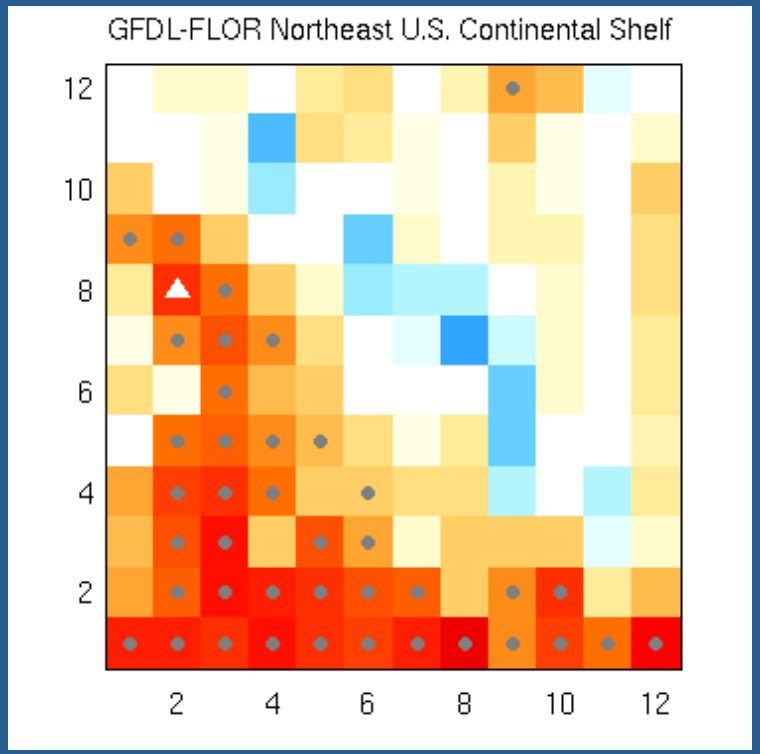
Persistence ACC



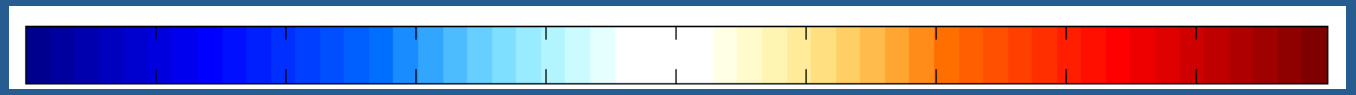
Forecast lead (months)

Forecast initialization month

GFDL-FLOR ACC

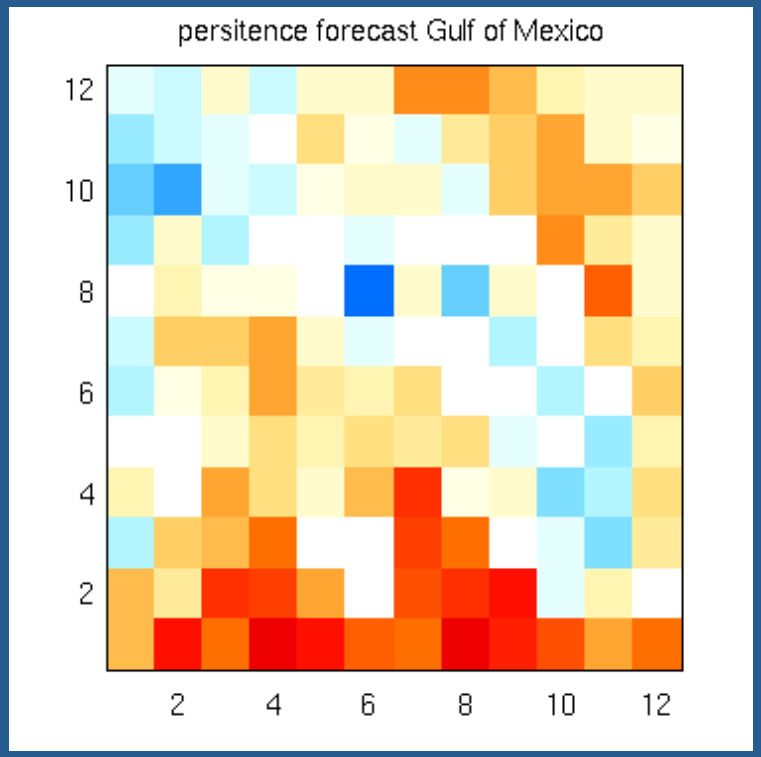


Forecast initialization month

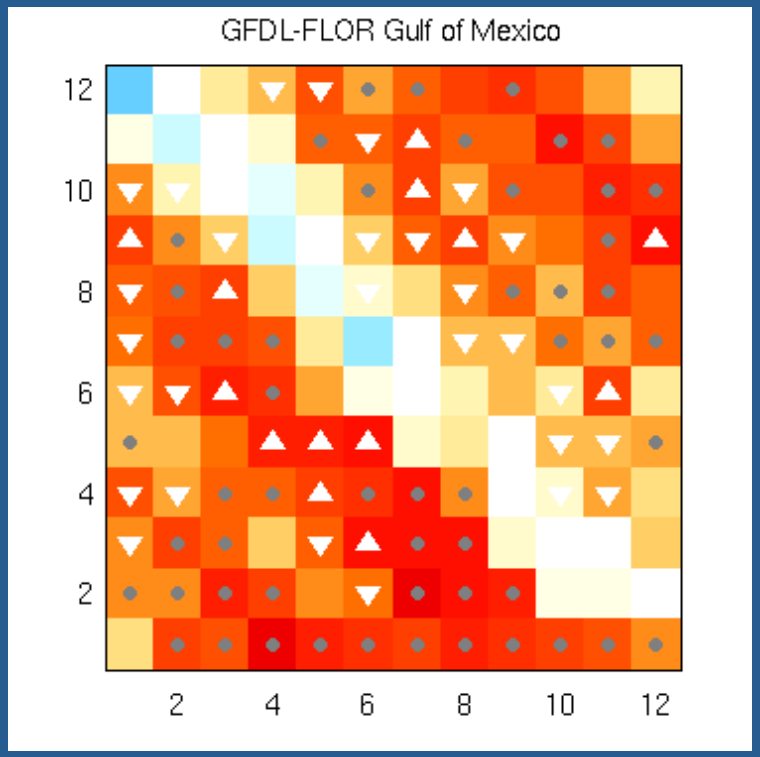


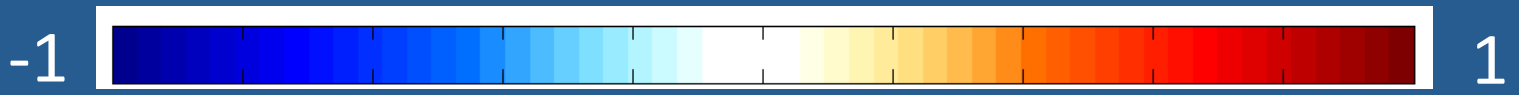
Multiple cases of skill above persistence in the Gulf of Mexico

Persistence ACC



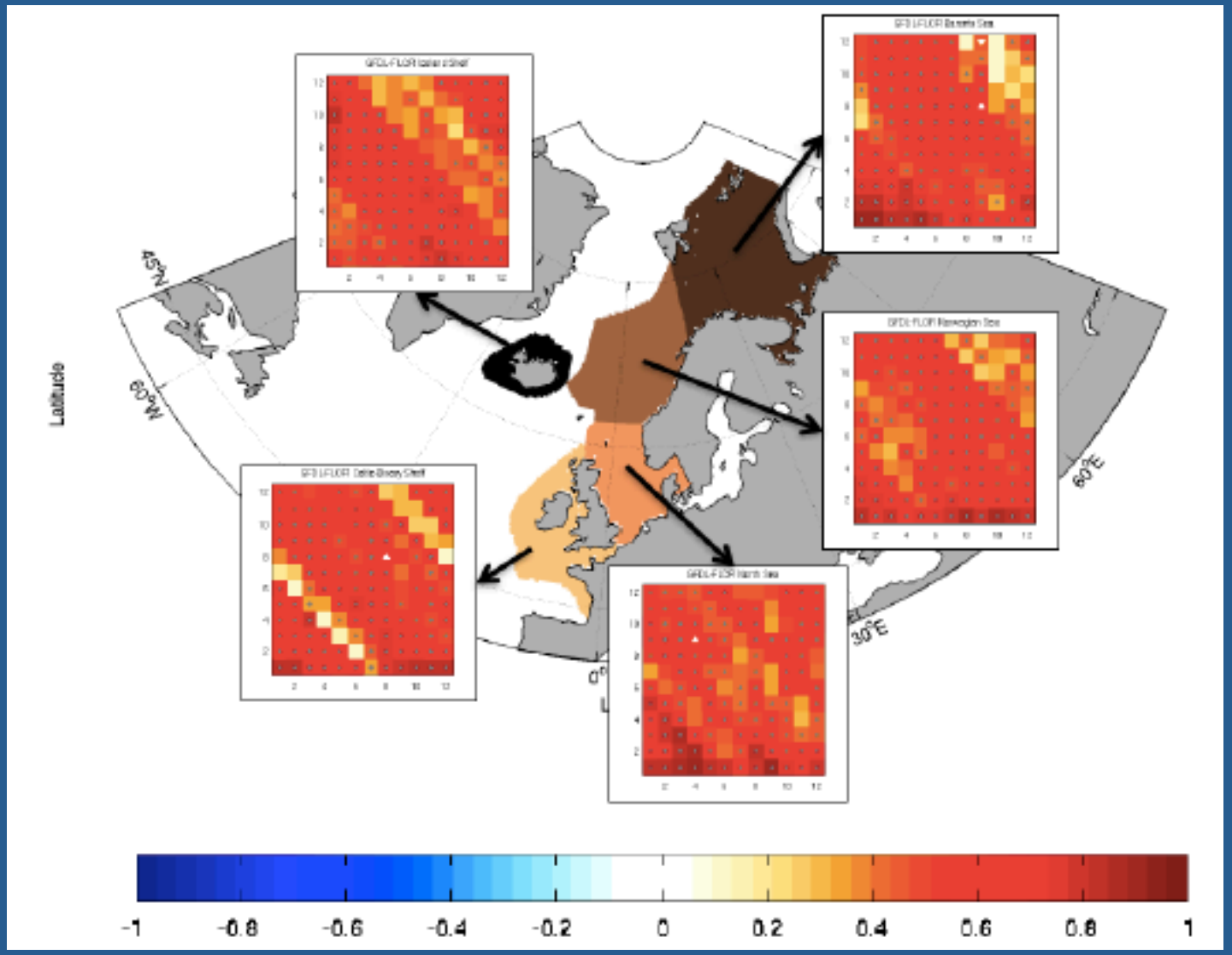
GFDL-FLOR ACC



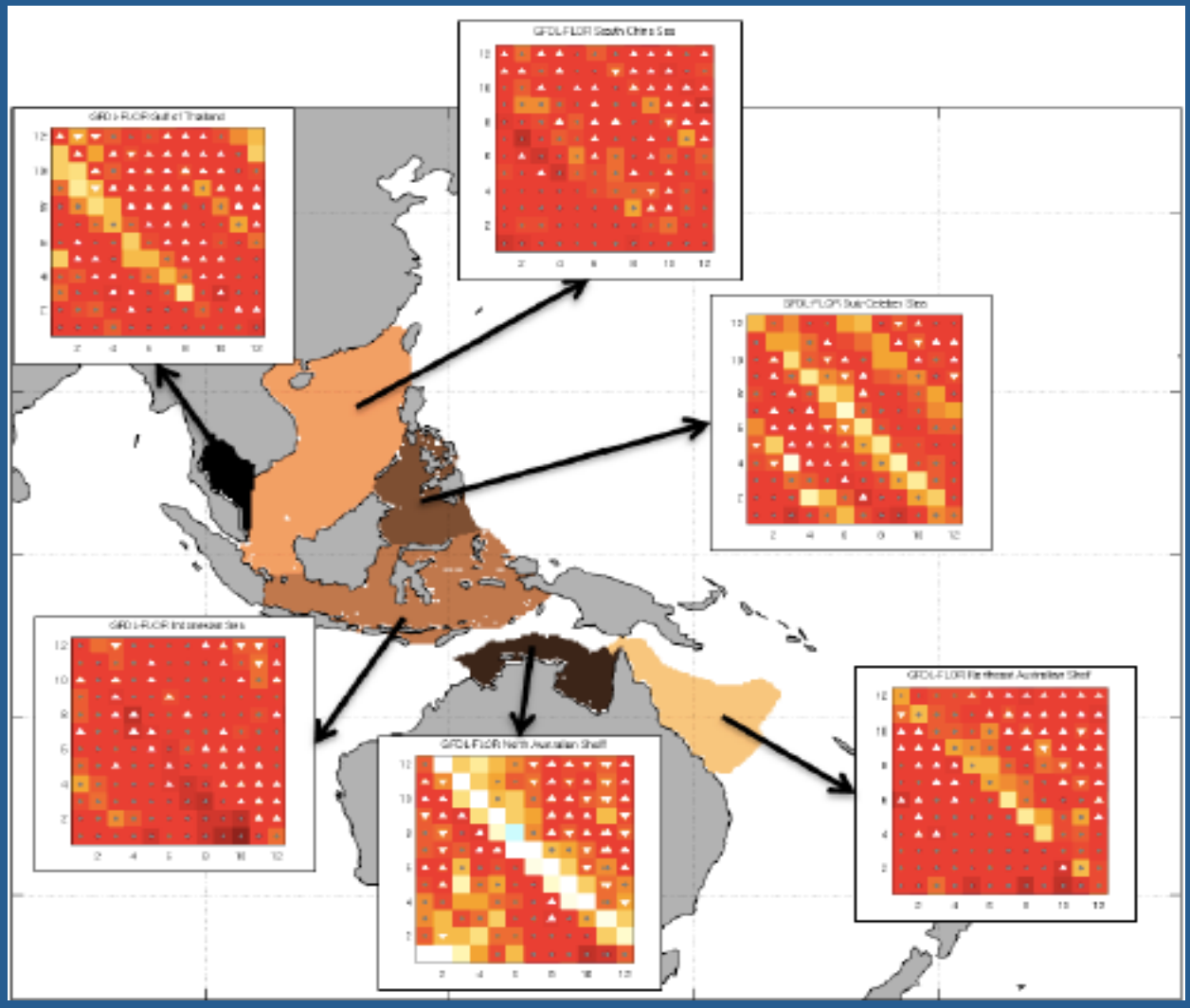


Some Global Highlights

High skill in the NW Atlantic, but rarely above persistence at seasonal scale



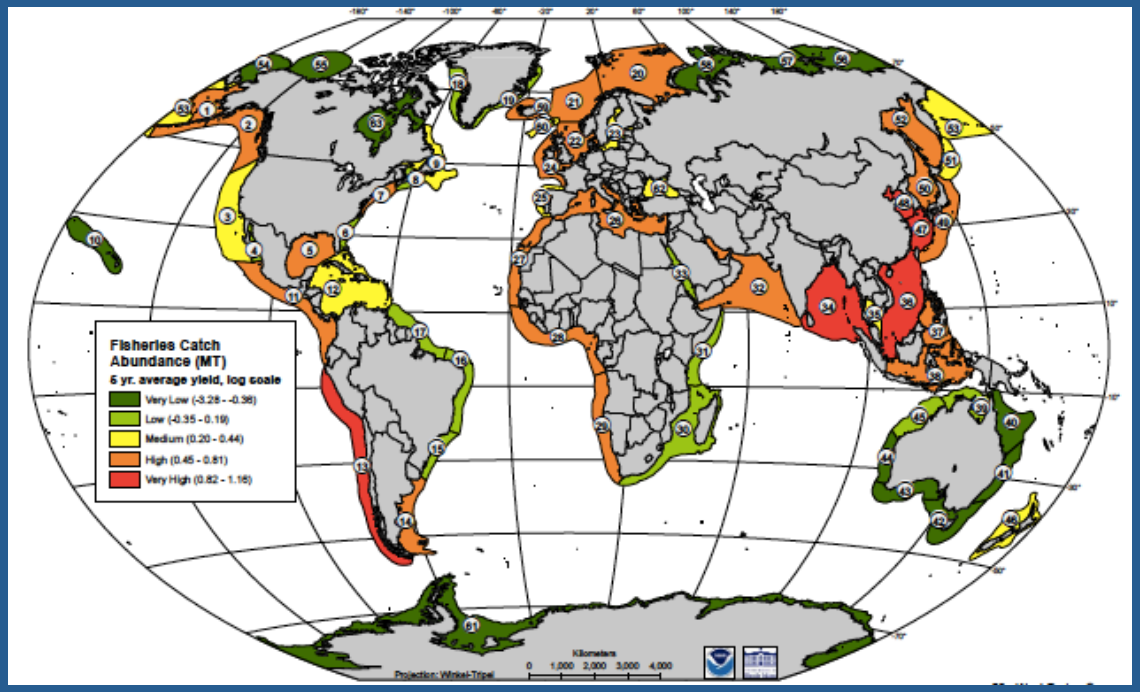
High skill in ENSO-influenced western tropical Pacific



Concluding thoughts

- Forecast skill varies widely by LME, initialization month, lead time and, to a degree, forecast system.
- There are many cases with high skill that also exceeds persistence. Analysis across 64 LMEs confirms this.
- Diverse mechanisms responsible for skill, but successfully capturing the interplay between local and basin-scale variation is a common thread.
- We had less luck with other variables, such as salinity, where even retrospective estimates often did not agree

Synthesize predictability across Large Marine Ecosystems (LMEs)



Large Marine Ecosystems: Useful ecologically influenced divisions of ocean areas, that are generally along continental margins, are widely applied in science and management, have off-shore boundaries that often correspond roughly with EEZ's, and account for ~70% of global fish are caught.